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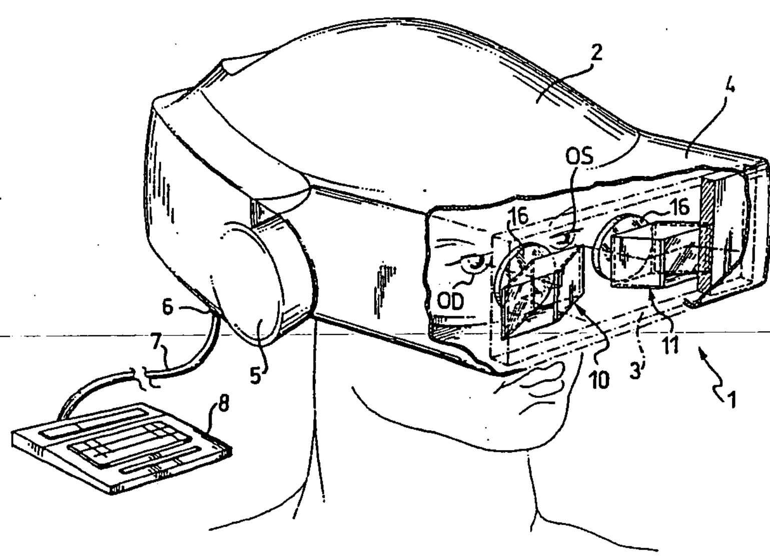
(54) Title: STEREOSCOPIC VISION DEVICE OF VIRTUAL REALITIES AND CORRESPONDING STEREOSCOPIC VISION METHOD



(57) Abstract

The invention relates to a device (1) for the stereoscopic vision of virtual realities, being of the type which comprises at least one display (3) of images representing the virtual reality, a stereoscope (9) interposed between the eyes (OS, OD) of a viewer and the display (3), and electronic means (8) of processing the images (I, I') connected to the display (3). The device (1) is a headpiece (2) incorporating the display (3) and stereoscope (9). In addition, the stereoscope comprises a pair of open prismatic bodies (10, 11) having reflective inner walls.

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Title of Invention

Stereoscopic vision device of virtual realities and corresponding stereoscopic vision method.

DESCRIPTION

Technical field

This invention relates to a device for the stereoscopic vision of virtual realities.

In particular, the invention concerns a device as above which comprises at least one display of images, representing such a virtual reality, and a stereoscope interposed between the eyes of a viewer and the display.

The invention also relates to a method for the stereoscopic vision of video images.

Background Art

As is known, the ability to view objects stereoscopically has long represented an alluring target for technicians and designers in a large variety of application fields, and especially so to all those concerned with the study and development of multimedial informatics.

Think for instance how would be valuable to visualize in a palpable three-dimensional manner the layout of objects and the directions of the drawing axes in an engineering project. Or of how useful the three-dimensional view of the objects may be in the archiectural field, in order to assess their efficacy or aesthetic effect. To this aim, the prior art has already proposed a first approach, as disclosed in German Patent No. DE 31 46 490, for example, wherein a pair of monitors are used, each arranged to

display the same object in a suitable spatial orientation. A set of deflecting mirrors, interposed between the viewer and the two monitors, allow for the right eye of the viewer to be only reached by the image from the right-hand monitor, and the left eye by that from the left-hand monitor, thereby providing a stereoscopic vision of the object.

While performing saitsfactorily, this prior technique has an obvious drawback in that it requires a pair of monitors.

Stereoscopic vision appears to have found of late a new and more specific application in the field of videogames and in the study and development of so-called virtual realities in connection with multimedial informatics.

In fact, the use of stereoscopic vision in videogames gives a viewer the impression of actually being part of a prearranged reality including multiple moving objects which draw near and far.

A prior approach which can be adapted for use in applications of this kind provides a single display screen to which different images are transmitted by a rapid oscillation of their frequency. The whole process is co-ordinated with the frequency of certain liquid crystal filters mounted in a stereoscope to be used by the viewer.

This arrangement has a drawback in that it involves very expensive and complex changes to the hardware for the display device.

Another prior approach is disclosed, for example, in European Patent Application No. 0 271 871, which concerns a device for the stereoscopic vision of color video pictures.

The last-mentioned approach provides for the use of a

single CRT or monitor, on which images to be watched with the right and the left eye, respectively, are displayed in the upper and lower portions of the screen.

In other words, the screen is split into two portions, an upper portion and a lower one, where the images for the right and the left eye of the viewer are respectively displayed. The screen is equipped with a vertical polarizing filter for the upper portion and a horizontal polarizing filter for the lower portion.

To gain a stereoscopic vision, the viewer is to don an eyeglasses frame of sort which comprises a polarizing lens for each eyepiece and a pair of parallel mirrors in front of each lens.

While being advantageous from several aspects, this prior approach still has some serious drawbacks, outstanding among which is that the use of filters and polarizing lenses makes it cost-intensive.

In addition, TV programs intended for three-dimensional vision must be transmitted with the picture already split in two parts, in order to put one of the two images out of sight of the eye which is to pick up the other image using the aforementioned polarizing filters.

It should also be remarked that the last-mentioned approach does not appear to be effectively applicable to the development of "virtual realities", that is to that particular facet of multimedial proposals which is concerned with the definition of prearranged environments and situations that are to supersede the reality in which the viewer finds him/herself for a predetermined period of time.

In practice, none of the prior art solutions reviewed hereinabove and directed to provide a stereoscopic vision of video pictures can allow the viewer to become visually isolated from his/her surroundings, and they inevitably end by being disappointing as far as the involvement of the viewer in a virtual reality of the three-dimensional type is concerned.

The underlying technical problem of this invention is to provide a device for the stereoscopic vision of virtual realities, and associated method for the stereoscopic vision of video pictures, which have such constructional and functional features as to overcome the limitations of similar prior solutions in a uniquely simple and economical manner.

Summary of the Invention

The solutive idea on which this invention stands is one of incorporating a stereoscope of particularly simple and cost-effective construction to a headpiece for viewing pictures representing a virtual reality.

Based on this solutive idea, the technical problem is solved by a device as indicated above and defined in the characterizing portion of Claim 1 and following.

The problem is also solved by a method for viewing video pictures stereoscopically as defined in the characterizing portion of Claim 17 and following.

The features and advantages of a device, and associated stereoscopic vision method, according to the invention will be apparent from the following detailed description of an embodiment thereof, given by way of example and not of limitation with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 is a perspective view showing, partly in section, a device which embodies this invention.

- Figure 1A shows a further perspective view of a different embodiement of the inventive device;

- Figure 1B is a perspective view showing schematically a detail of the inventive device.

- Figure 2 shows, schematically and to an enlarged scale, a display as incorporated to the device in Figure 1.

- Figure 3 shows schematically the right and left eye visions of a viewer who is using the device of this invention.

- Figure 4 shows the same as in Figure 3, in a different condition of use.

- Figure 5 is a perspective view of a detail of the inventive device, taken from the viewer's end.

- Figures 6 and 7 are respective perspective views of the internal mechanism of the detail in Figure 5.

- Figure 8 is a further perspective view of another embodiment of this invention.

Detailed Description

With reference to the drawing views, generally and schematically shown at 1 is a device embodying this invention for the stereoscopic vision of virtual realities.

The device 1 comprises a headpiece 2 for donning by a viewer. Later in this description, the headpiece 2 will

also be referred to as the HMD (Head Mounted Display) or the HCD (Head Coupled Display).

The headpiece 2 incorporates at least one display 3, which is supported in front of the viewer's eyes OS, OD, at a predetermined distance therefrom. The display 3 comprises, of preference, a liquid crystal screen 19, but it may also be a cathodic tube. The display is accommodated essentially on the bottom of a box-type enclosure or body 4 which is integral with the headpiece 2 and juts out therefrom in a front position.

Electronic control circuits for the display 3 are incorporated to a computerized central unit 8 which is connected electrically to the headpiece 2. The unit 8 may also be a computer of some conventional type.

Through a suitable image processing program, two discrete images I, I' of the same object can be represented side-by-side on the display 3. In essence, it is as if the screen of the display 3 were split into two portions 12, 13, each containing a different image of the same object, as shown in Figure 1A.

The headpiece 2 also incorporates earphones 5 and quick-connect means 6 for interconnection with a connector 7 from the computerized unit 8. Through the connector 7, the central unit 8 can be two-way connected to the internal electric apparatus 3 and 5 of the headpiece 2.

Advantageously, according to the invention, the headpiece 2 further incorporates a stereoscope 9, i.e. an instrument affording a three-dimensional vision of the images displayed on the display 3. The stereoscope 9 would, of course, be interposed and supported on the headpiece 2 between the viewer's eyes OS, OD and the display 3.

Magnifying lenses 16 are optionally arranged behind the stereoscope to provide a sharper picture or a wider field of vision for the viewer.

The stereoscope 9 has a particularly simple and inexpensive construction and comprises basically two prismatic bodies 10 and 11, the one for the right eye OD and the other for the left eye OS. These bodies are made of a synthetic plastics material, such as Plexiglas (a registered trademark).

The bodies 10 and 11 are open along parallel directions to the screen 19 and have a pair of reflective inner walls, confronting each other to reflect light rays impinging on each of the viewer's eyes OS, OD.

Furthermore, in a preferred embodiment to be described in greater detail, these reflective walls are movable in a guided fashion toward and away from each other. One of them is also displaceable angularly with respect to a symmetry axis X of the stereoscope.

In a second embodiment, to be described herein below with particular reference to Figures 1A and 8, the prismatic bodies 10, 11 are tied together by a supporting structure 36 provided with means 38 of releasable hooked connection to an eyeglasses frame 39 to be donned by the viewer for supporting the lenses 16. The means 38 comprise small hooks straddling the lenses 16 at the location of the frame nosepiece.

Two little masks 40, one for each body 10, 11, are slidebly guided on the front wall of the structure 36. Each mask interferes with the opening space of each body toward the display 3.

Such masks are specifically arranged to partially reduce the passing light of the vision cone to prevent interference between the vision field of an eye and the image for the other eye. Of course, nothing prevents from realizing the frame 39 with the prismatic bodies 10, 11 integrally formed with the ocular seats of the lens. A rigid structure 36 shall anyway be provided to maintain the parallelism between such bodies.

With specific reference to Figure 1A, the displaying method of this invention as applicable to the three-dimensional vision of images displayed on the screen 19 of a computer monitor 20, will now be discussed.

In this case, the stereoscope 9 is schematically represented by a double pair of parallel mirrors 22, 23 which extend vertically and lie between 43° and 47°, and preferably at 45°, to a symmetry axis X of the sterescope. Such an axis is perpendicular to a plane containing the screen 19.

More particularly, the inside mirror 22 is inclined at an angle, with reference to the X axis, which is minor than the inclination angle of the outer mirror 23, preferably such an angle is of 41° and anyway between 40° and 42°. This disposition allows to obtimize the stereoscopic vision of viewers having different intepupillary distances.

A computer, forming the central unit 8, incorporates for instance a microprocessor of the type available commercially as Intel's Model 80486, with a mathematical co-processor and a RAM storage capacity of at least 640 kilobytes. A purposely provided graphic image processing program, e.g. of the "AUTOCAD" type, is installed in the computer so that the images can be presented on the monitor 20 in a desired manner.

Through the commands of the AUTOCAD program, an image whichever, preliminarly defined and stored, e.g. the three-dimensional plans of a house or the own environment of a virtual reality, can be displayed on the screen 19 as if sighted through a movie or a still camera from a selected point. This viewpoint is called the "camera point", while the point at which the still camera is aimed is called the "target point".

More particularly, in accordance with this invention, two different images, I and I', of the same object are displayed on the screen 19. In essence, the screen 19 is split into two portions or frames lying side-by-side and showing the same object.

Figure 2 illustrates schematically such a situation, and the respective target points of each image are denoted by A and A' therein.

In order to shift the image I within its frame, the relative target points and camera points of the image must be traslated of a same distance, such as the distance between the pupillars. Various possibilities for displacement are offered as working options of the AUTOCAD image handling program: for example, the left-hand image can be rotated a few degrees about the target point, and a similar but oppositely directed rotation can be imparted to the right-hand image automatically. As an alternative, as already said, it's possible to parell translate the target points and camera points.

By using the fixed mirror stereoscope 9, aimed at the center of the screen 19, the viewer is allowed to see the object in three-dimensional form.

However, bringing the target points closer to each other

results in image portions, e.g. those denoted by C and C' in Figure 2, disappearing from the respective frames, so that the three-dimensional effect would be limited to the central area of the object under observation.

Advantageously, this problem is solved, in accordance with the invention, by a modified embodiment of the stereoscope shown schematically in Figure 4.

In this embodiment, the target points are drawn near one to other by the program while the inner mirrors 22 are adjustable manually both for movement toward and away from the outer mirrors 23, and for inclination with respect to the symmetry axis X of the stereoscope.

Thus, a convergence of the viewer's eyes can be obtained which corresponds to the apparent distance from the object displayed on the screen 19.

In fact, the viewer can adjust the spacing of the inner mirrors 22 from the outer mirrors 23 according to the spacing between his/her own eyes, usually at 6,3 cm from each other with a variation of ±10% between individuals.

Also, should the viewer wish to effect a rotation of the displayed object, e.g. a four-degree rotation -- two positive degrees for the left eye and two negative degrees for the right eye -- a like convergence adjustment of the inner mirrors 22 is recommended in order for the object to be viewable without eyestrain. If the mirrors were rotated without shifting the visual cones, they would fail to be centered on the viewer's pupillars, and therefore, make the stereoscopic effect impossible to achieve.

The virtual distance d at which the object locates as a function of the degrees g of rotation applied to an image I

relative to the other image I' can be computed by the following formula:

(6,3 / 2)/d = tg(g/2)

where, 6,3/2 is the average nose-to-eye distance, and d is the average distance of the object from the viewer's nose in centimeters.

The ratio of these two distances is, therefore, the tangent of the angle through which the image seen by the human eye is rotated in the assumed case that it is viewed from the nose position.

Since at close-ups, the difference between the images and the eye convergence may begin to be unpleasant, the capability to incline the inner mirrors 22 to the symmetry axis X, causing the eyes to converge by the same angle as the image rotation, is specially useful and appropriate.

A preferred embodiment of the adjustable mirror stereoscope will now be described with reference in particular to the examples shown in Figures 5 and 6.

The mirrors 22 and 23 of the stereoscope are housed inside an elongate parallelepipedal body 15 having a base 14 and a cover 17. The mirrors 22 and 23 lie perpendicularly on the base 14 and at an angle of 45 degrees to the symmetry axis X of the stereoscope.

Each of the outermost mirrors 23 is carried on a pair of rods 18 extending in parallel close against the base 14 and being guided for movement in respective guides 27 rigid with the base 14. At least a third rod, not shown in the drawings, is provided close against the cover 17 and slidable within a corresponding guide rigid with the cover. All these parts are made of a self-lubricating plastics

material.

A guide pin 24, secured centrally on the mirror 23 top, is passed through a slotted hole 31 in the cover 17.

A ring nut 25, serrated or knurled around its periphery, is made fast with the pin and can be reached by the user to shift the mirror 23 along the direction set by the slotted hole 31 perpendicularly to the axis X.

An indexed scale 29 allows the position of a mark, provided integral with the pin 24 and visible through an elongate opening 28 substantially parallel with the hole 31, to be identified. Thus, the mirrors 23 are guided for movement toward and away from each other to ensure precise centering of images generated on screens 19 of varying sizes, or of images on the same screen but to different sizes.

As for the innermost mirrors 22, these are also carried on opposed rods 26 parallel with the base 14 and the cover 17. These rods 26 are slidable within guides 37 made fast with the base 14 and the cover 17, respectively.

For these mirrors 22, opposed pivot pins 32 are also provided which fit into corresponding seats formed in the rods 26. In this way, the mirrors 22 are allowed a rotary/translatory range of movement relative to the axis X.

Furthermore, the mirrors 22 are connected to each other by a pair of telescoping arms 34 which have opposite ends provided with hinges, in turn attached to the mirrors 22. A serrated or knurled ring nut is mounted centrally on each arm 34.

Advantageously, according to the invention, the drives which enable the mirrors 23 and 22 to be slid and rotated

are linked operatively to electric motors, not shown because conventional, which are controlled by respective outputs from the microprocessor incorporated to the central unit 8.

Specifically, the central unit 8 is provided with a parallel or serial output, similar to that used for controlling peripheral units, e.g. graphic printers equipped with paper movement platens and carriage shift.

The interior of the headpiece 2 accommodates instead integrated circuits adapted to recognize pulses from such an output. Well, the stereoscope incorporated to the headpiece 2 is provided with electric motors controlled by the outputs from such mirror setting circuits.

The device of this invention does solve the technical problem and affords a number of advantages, outstanding among which is that it makes the use of expensive polarizing filters, or filters of any other types, unnecessary.

Another important advantage is that the internal construction of the display devices, whether monitors or liquid crystal displays, is kept unaltered, it being no longer necessary to change the hardware of such devices. The facility of using, the adjustability to each type of display and the transportability confer to the inventive device great advantages.

In addition, from the standpoint of image processing, processing programs can be used which are already available commercially, such as CAD programs which allow images of objects represented in perspective form to be processed. In other words, each images processing software may be used with the present invenztion.

Finally, the inventive device effectively affords a three-dimensional vision of virtual realities, it being implemented as a headpiece which isolates the viewer from his/her surroundings.

Understandably, the device and method of this invention may be altered and modified within the scope of the appended claims.

CLAIMS

1. A device (1) for the stereoscopic vision of virtual realities, and of the type which comprises at least one display of images representing said virtual realities, a stereoscope (9) interposed between the eyes (OS,OD) of a viewer and the display (3), and electronic means (8) of processing said images (I,I') connected to the display (3), characterized in that it is a headpiece (2) incorporating the display (3) and stereoscope (9), on which two side by side images are shown, and that said stereoscope comprises a pair of open prismatic bodies (10,11) having reflective inner walls.

2. A device according to Claim 1, characterized in that said inner walls are a pair of parallel mirrors (22,23) facing each other and lying essentially between forty-three and fourty-seven degrees to a symmetry axis (X) of the stereoscope (9).

3. A device according to Claim 2, characterized in that the innermost mirror (22) with respect to the symmetry axis (X) is adjustable by displacement relative to the outermost mirror (23).

4. A device according to Claim 2, characterized in that the innermost mirror (22) with respect to said symmetry axis (X) is displaceable angularly with respect to said axis (X). 5. A device according to Claim 2, characterized in that the outermost mirrors (23) of the pair of prismatic bodies (10,11) are guided for movement toward and away from each other to adjust the stereoscope (9) for varying sizes of the displayed image.

6. A device according to Claim 1, characterized in that at least one (22) of said inner walls is displaceable

angularly with respect to the symmetry axis (X) of the stereoscope.

7. A device according to Claim 1, characterized in that it includes respective magnifying lenses (16) placed between the eyes (OS,OD) of the viewer and the stereoscope.

8. A device according to Claim 2, characterized in that said mirrors (22,23) are connected drivingly to electric motors controlled by electric signals from said electronic means (8).

9. A device according to Claim 1, characterized in that said prismatic bodies (10,11) are tied together by a supporting structure (36) provided with means (38) for releasable hooking to an eyeglasses frame to be donned by the viewer.

10. A device according to Claim 1, characterized in that the innermost wall of said prismatic bodies (10, 11) is disposed at an angle to the axis (X) of the stereoscope which is minor than the inclination angle of the outer wall.

11. A device according to Claim 10, characterized in that said angle is in a range which varies from 40° to 42°.

12. A device (1) for the stereoscopic vision of virtual realities, and of the type which comprises at least one display of images representing said virtual realities, a stereoscope (9) interposed between the eyes (OS,OD) of a viewer and the display (3), and electronic means (8) of processing said images (I,I') connected to the display (3), characterized in that the stereoscope (9) comprises a frame (39) for glasses and a pair of open prismatic bodies (10,11), having reflective inner walls, integrally formed

with the frame (39).

13. A device according to Claim 12, characterized in that such prismatic bodies (10, 11) are fixed by a common rigid structure (36) removably hanged on said frame (39).

14. A device according to Claim 12, characterized in that it comprises respective mask (40) slidably guided on the front wall of said structure (36) and each interfering with the opening of the corresponding prismatic body.

15. A device according to Claim 12, characterized in that the innermost wall of said prismatic bodies (10, 11) is disposed at an angle of only 41 ° with reference to the axis (X) of the stereoscope.

16. A device according to Claim 12, characterized in that the innermost wall of said prismatic bodies (10, 11) is disposed at an angle to the axis (X) of the stereoscope which is minor than the inclination angle of the outer wall.

17. A method for the stereoscopic vision of video images, particularly useful for videogame or virtual reality applications, of the type which is implemented by using at least one display (3), a stereoscope (9) provided with mutually facing reflective walls (22,23), and computerized means (8) for processing display images, characterized in that it comprises the steps of:

- displaying two side-by-side images (I,I') on the display;

- translating in the perspective space a few degrees of the camera point of one image (I) away from the other image (I'); and setting the viewer in front of the display;

- adapting the distance (d) of the viewer from the display

according to the size of the image and in such a manner that the visual cone of the right eye looks only the right image, and the visual cone of the left eye look only the left image.

18 Method according to claim 17, characterized in that the co-ordinating movement of said reflective walls (22,23) with the rotation of the images (I,I') on the display (3) is under the control by said means (8) and according to the apparent distance (d) of the images from the viewer.

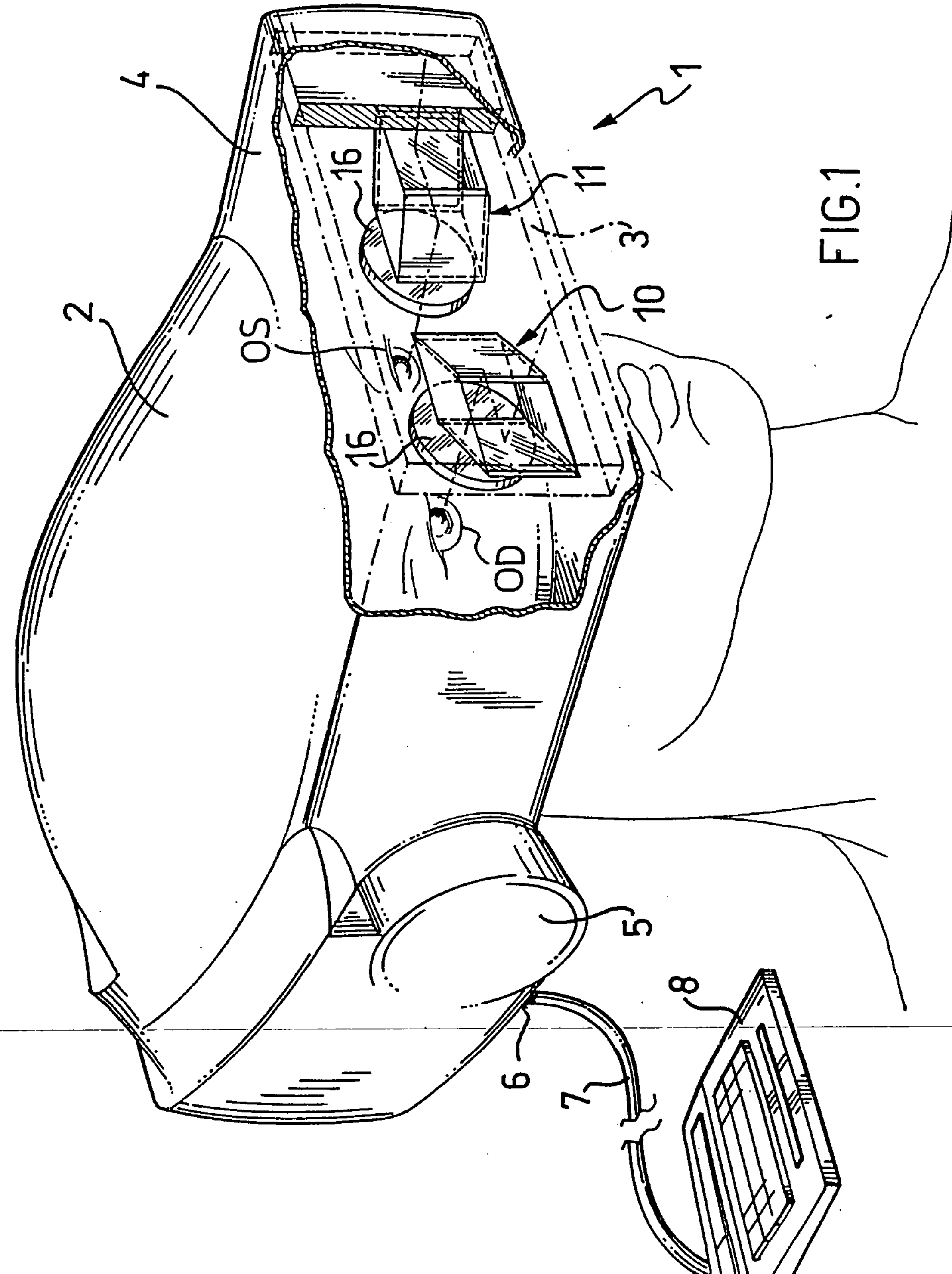

FIG.1

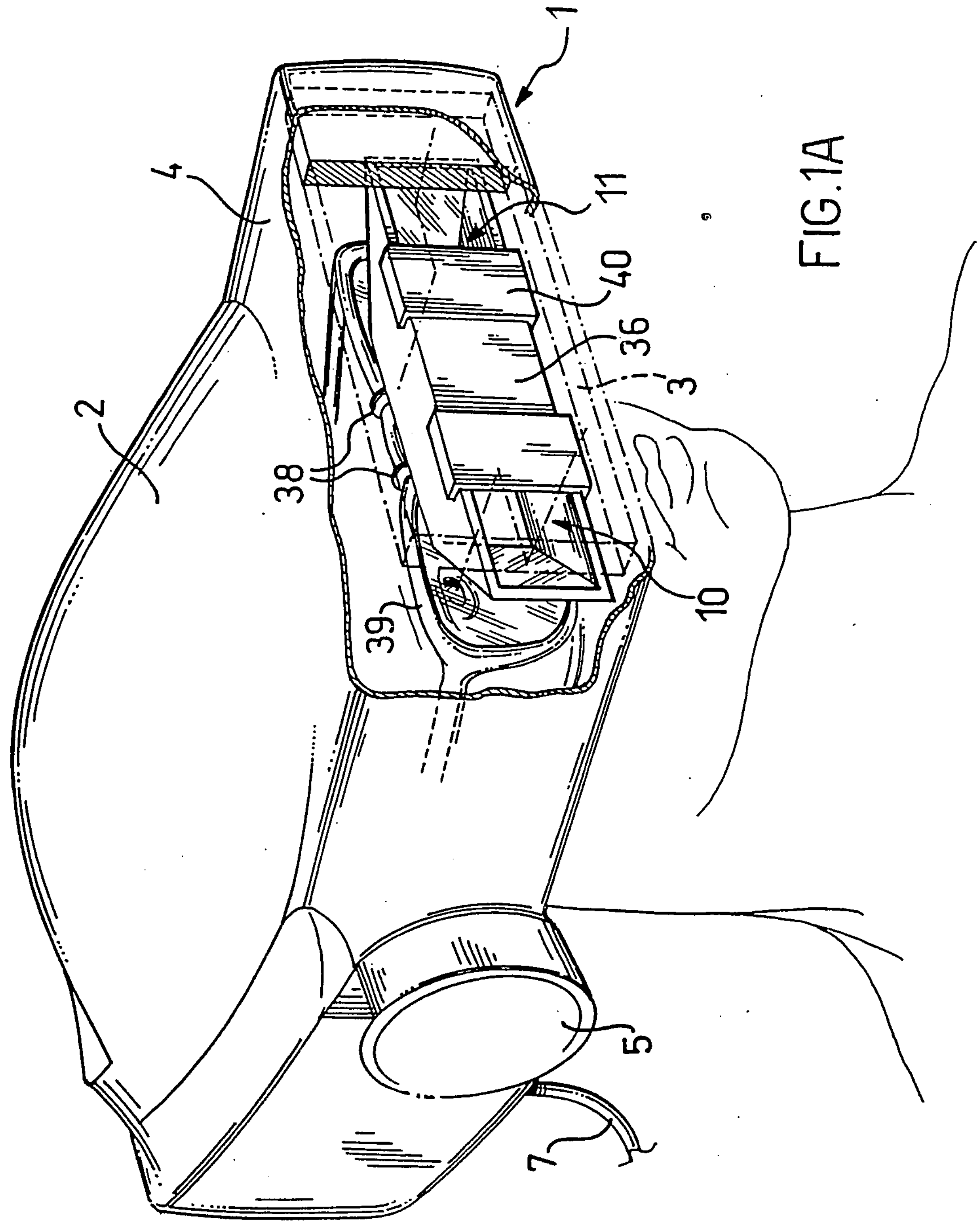

FIG.1A

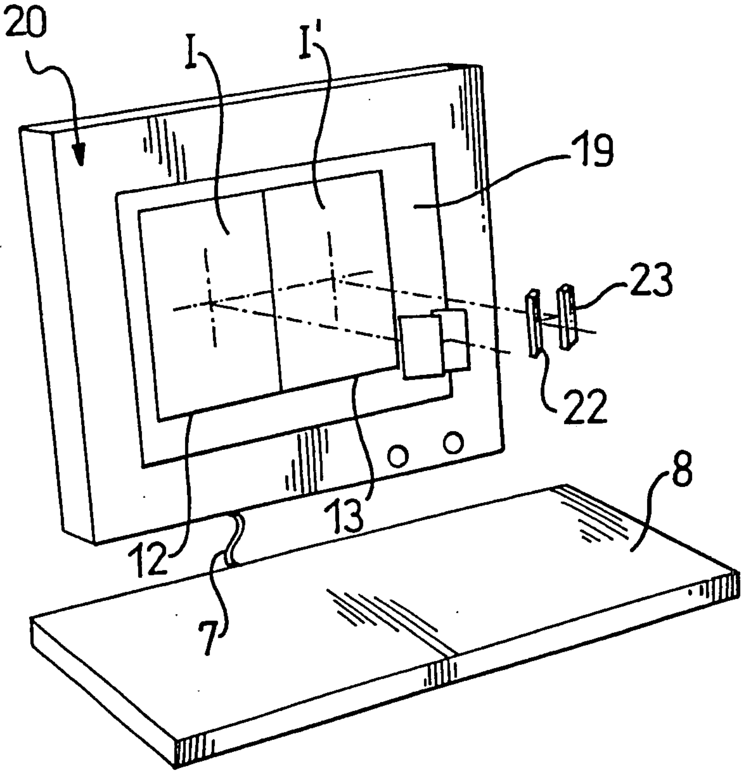

FIG.1B

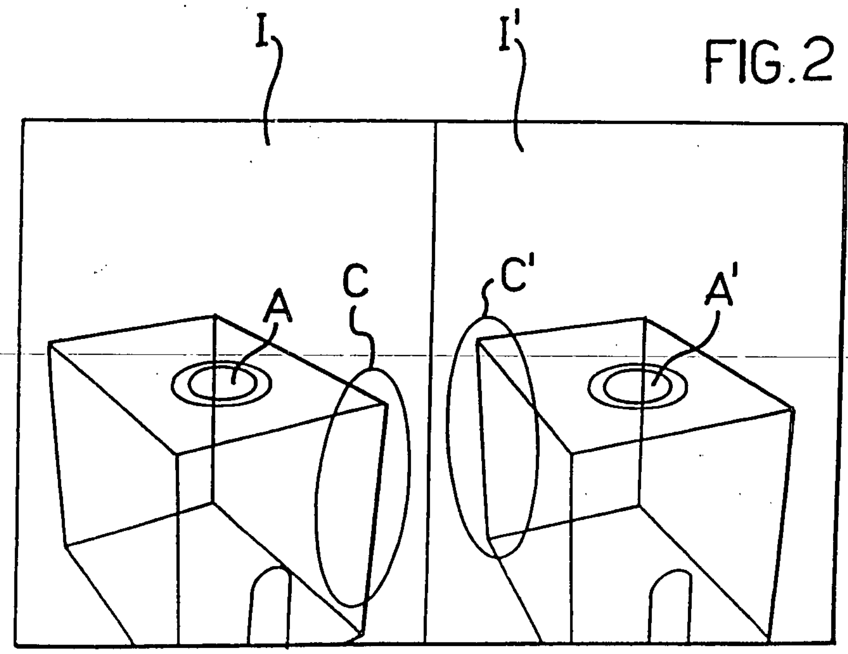

FIG.2

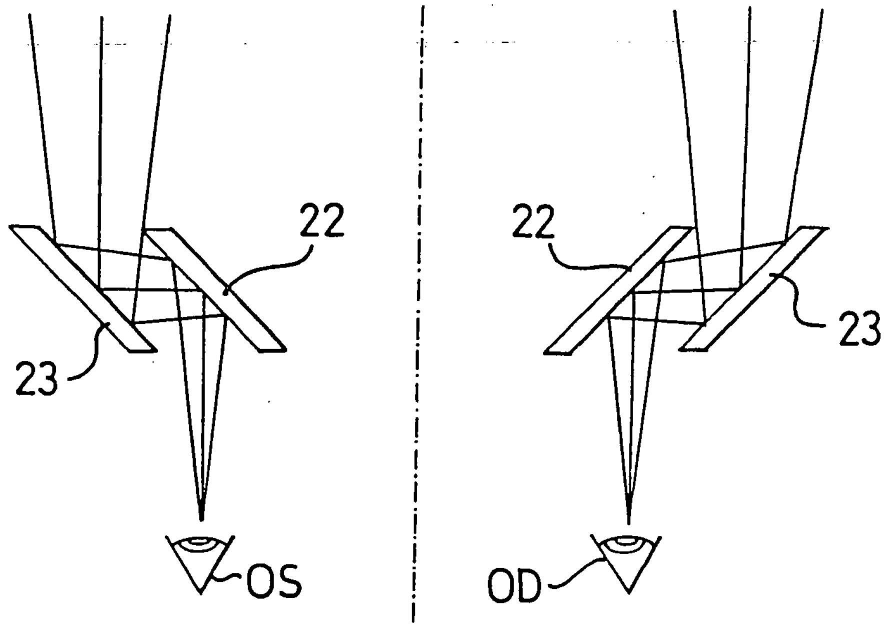

FIG.3

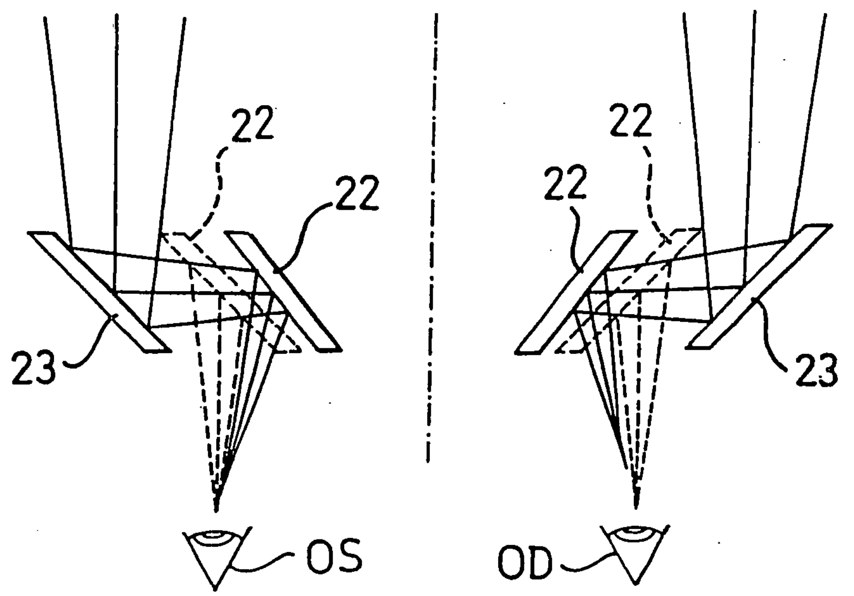

FIG.4

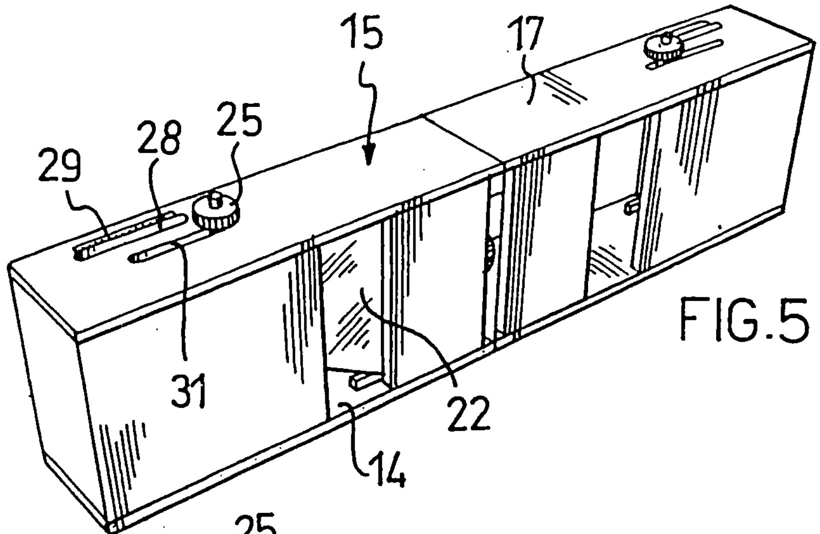

FIG.5

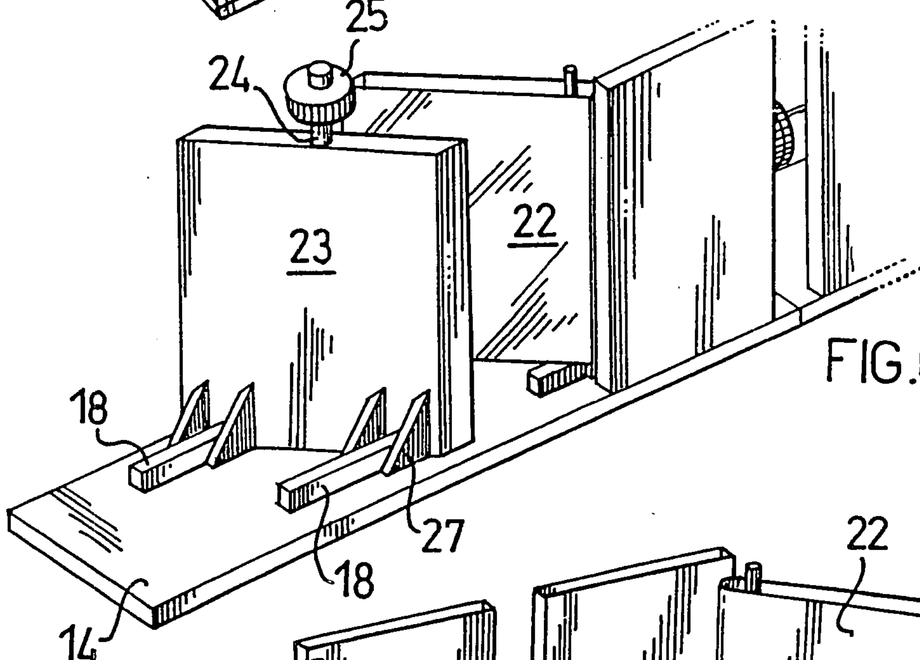

FIG.6

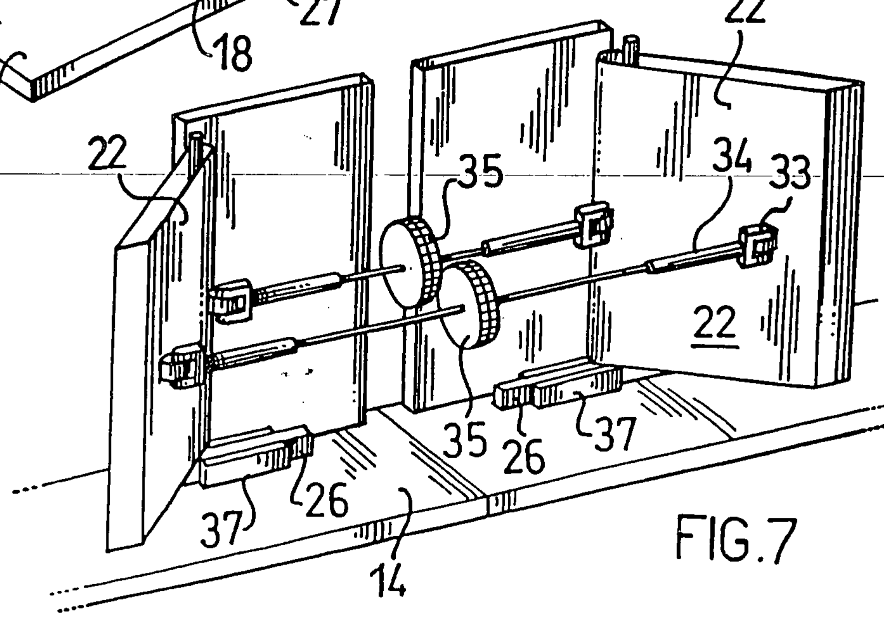

FIG.7

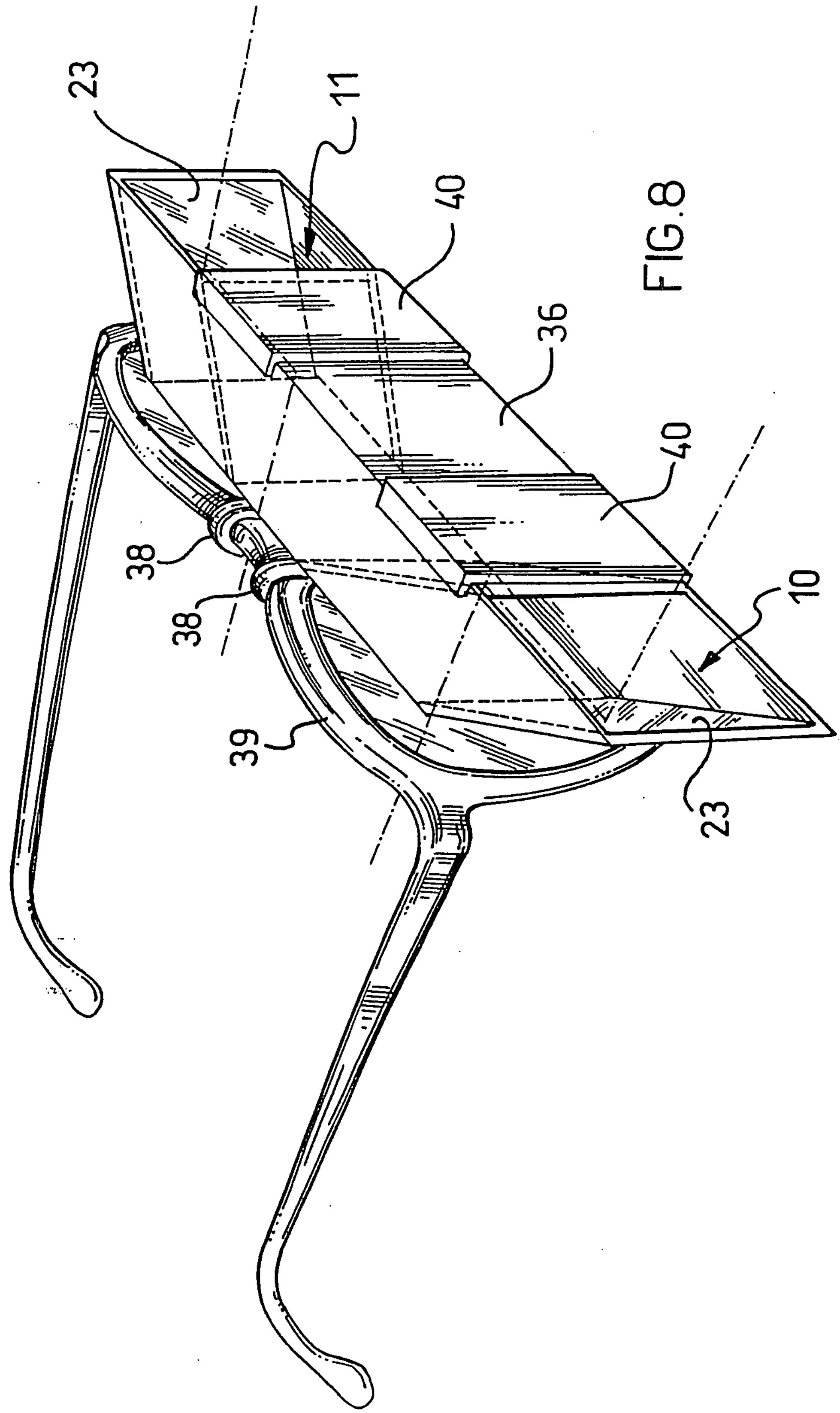
23
11
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FIG.8
36
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 G02B27/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 G02B G09B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP,A,0 539 907 (KABUSHIKI KAISHA SEGA ENTERPRISES) 5 May 1993 see abstract; claims 6-9; figures 1-4 see column 4, line 34 - column 5, line 38 ---	1-7,12
Y	WO,A,90 15356 (D.E.TRUMBULL, L.LICHTENFELD) 13 December 1990 see abstract; claims 1,2,5,7; figures 1-3 see page 9, line 12 - line 26 see page 12, line 8 - line 13 ---	1-7,12
A	EP,A,0 366 467 (GEC-MARCONI LTD) 2 May 1990 see abstract see column 3, line 33 - line 38 --- -/--	1,12

[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 September 1994	12.10.94

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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